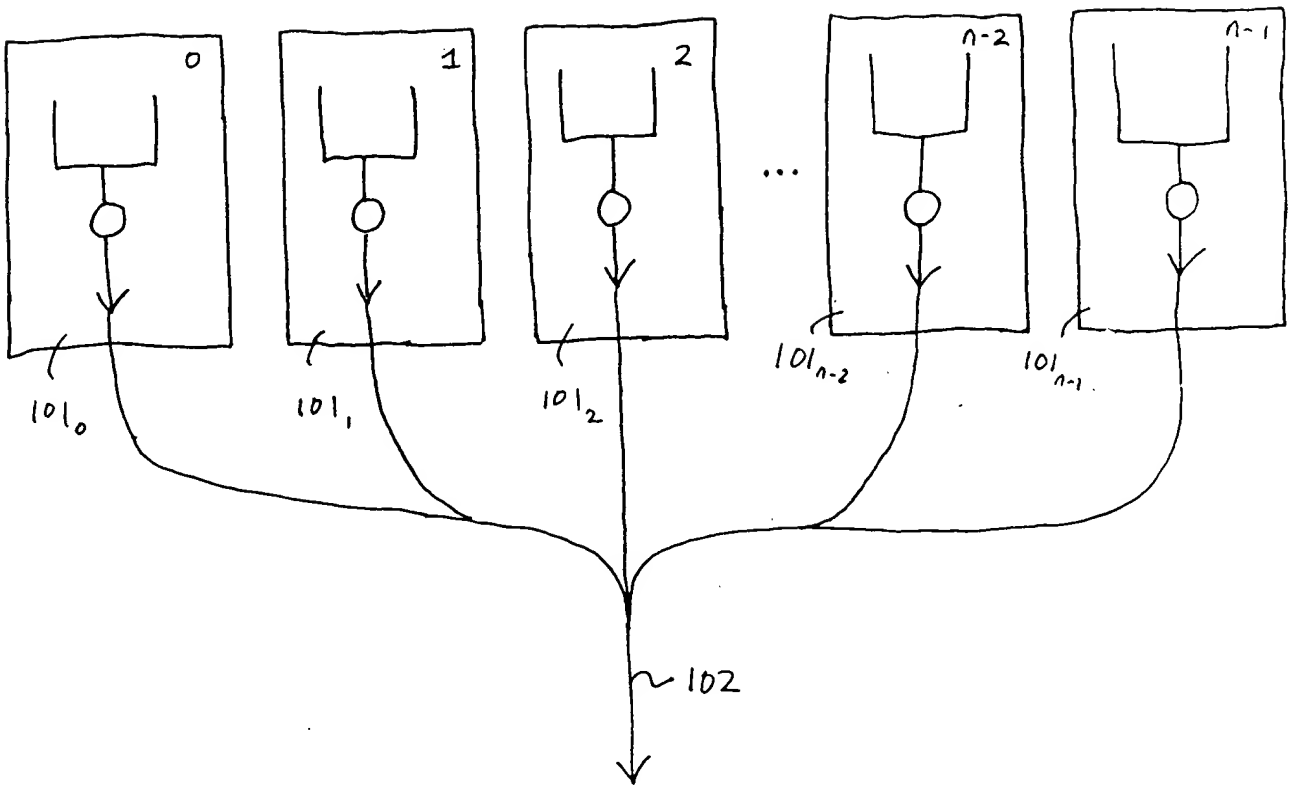

FIGURE 1

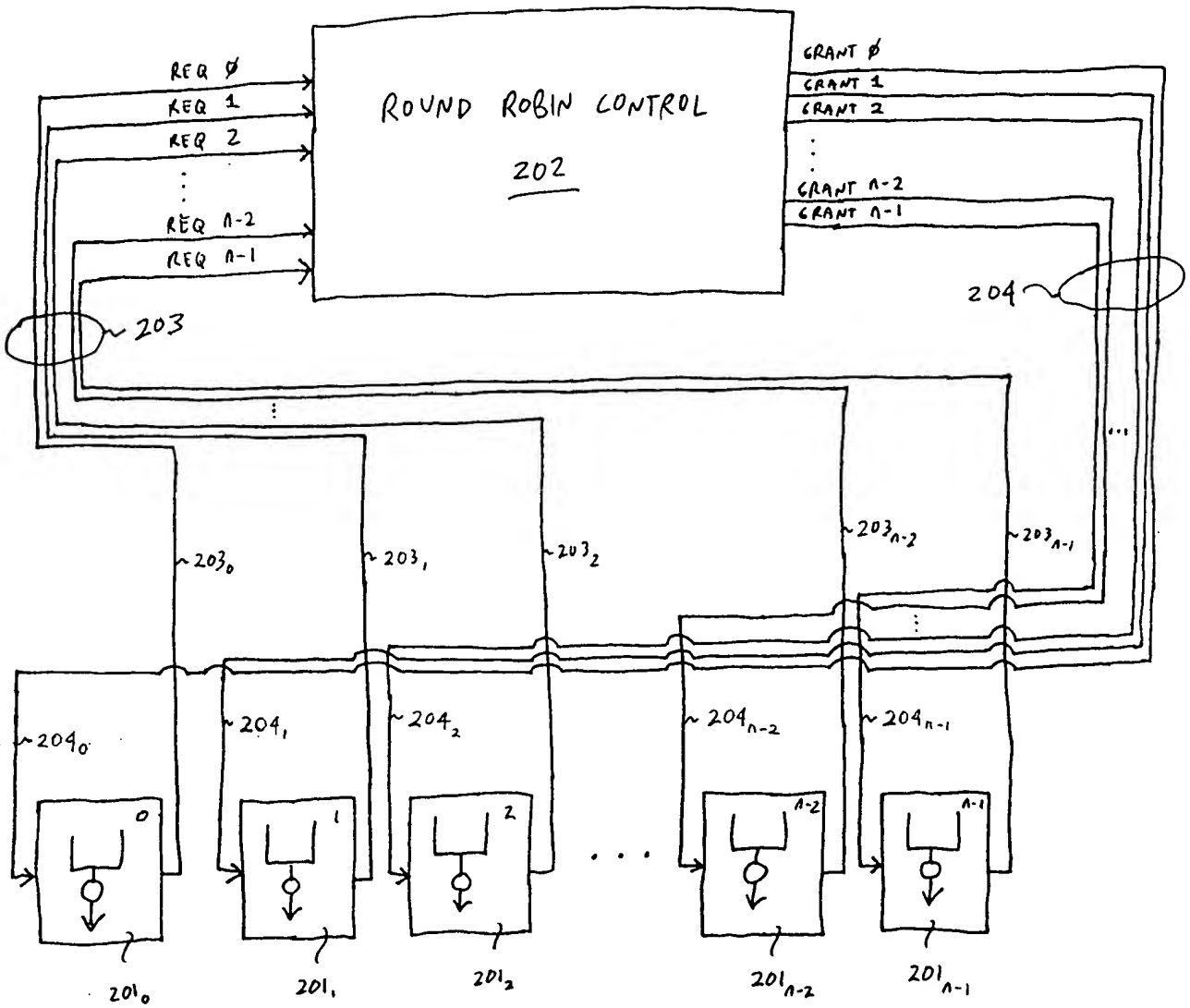
ROUND ROBIN CONTROL
202
REQ 0
REQ 1
REQ 2
REQ n-2
REQ n-1
GRANT 0
GRANT 1
GRANT 2
GRANT n-2
GRANT n-1
203
204
203_0
203_1
203_2
203_{n-2}
203_{n-1}
204_0
204_1
204_2
204_{n-2}
204_{n-1}
0
1
2
n-2
n-1
201_0
201_1
201_2
201_{n-2}
201_{n-1}

FIGURE 2

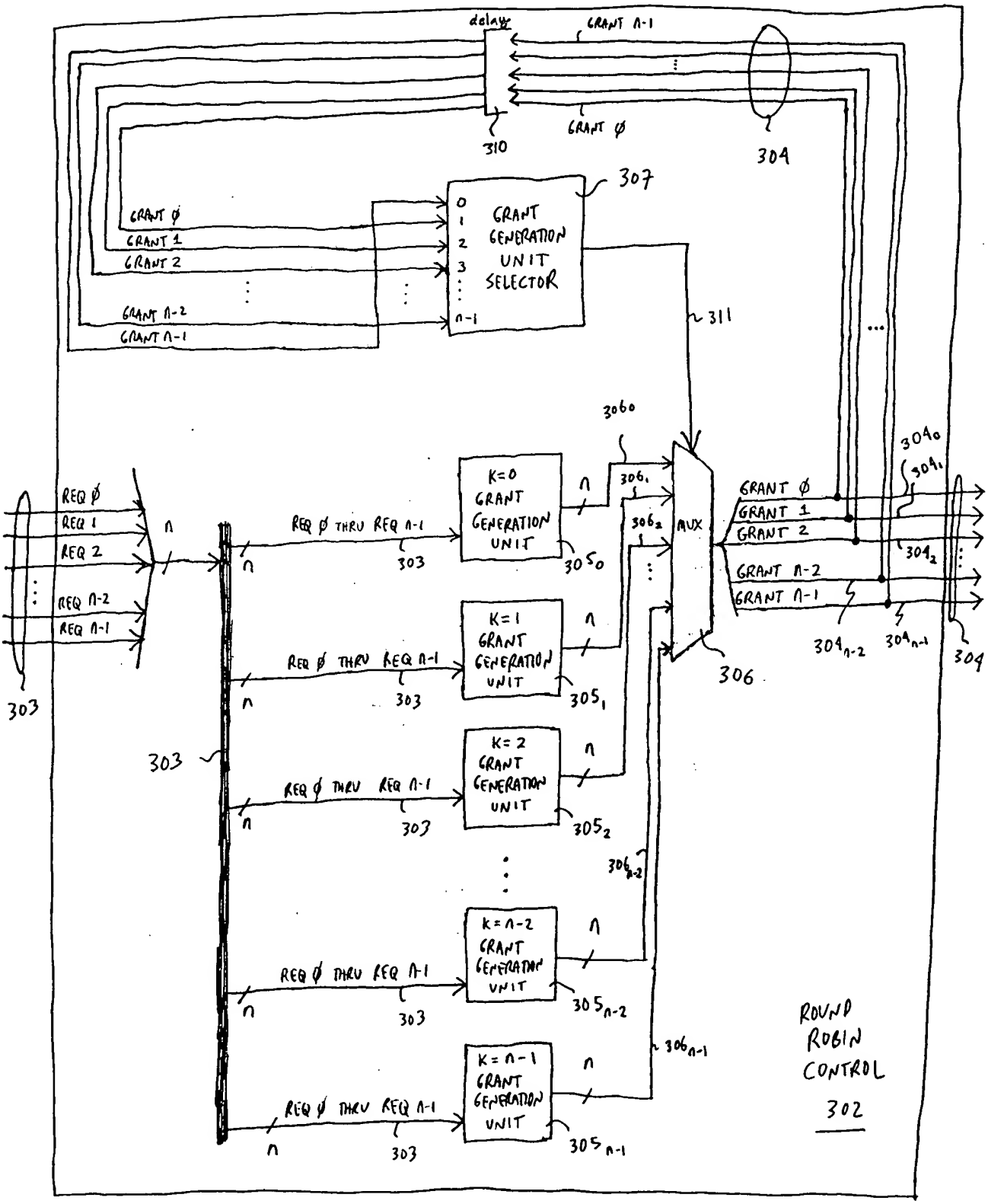
delay
GRANT n-1
GRANT 0
310
304
307
GRANT 0
GRANT 1
GRANT 2
GRANT n-2
GRANT n-1
0
1
2
3
n-1
GRANT GENERATION UNIT SELECTOR
311
3060
REQ 0
REQ 1
REQ 2
REQ n-2
REQ n-1
303
n
REQ 0 THRU REQ n-1
K=0 GRANT GENERATION UNIT
K=1 GRANT GENERATION UNIT
K=2 GRANT GENERATION UNIT
K=n-2 GRANT GENERATION UNIT
K=n-1 GRANT GENERATION UNIT
305 0
305 1
305 2
305 n-2
305 n-1
306 1
306 2
306 n-2
306 n-1
MUX
306
GRANT 0
GRANT 1
GRANT 2
GRANT n-2
GRANT n-1
304 0
304 1
304 2
304 n-2
304 n-1
304
ROUND ROBIN CONTROL
302

FIGURE 3a

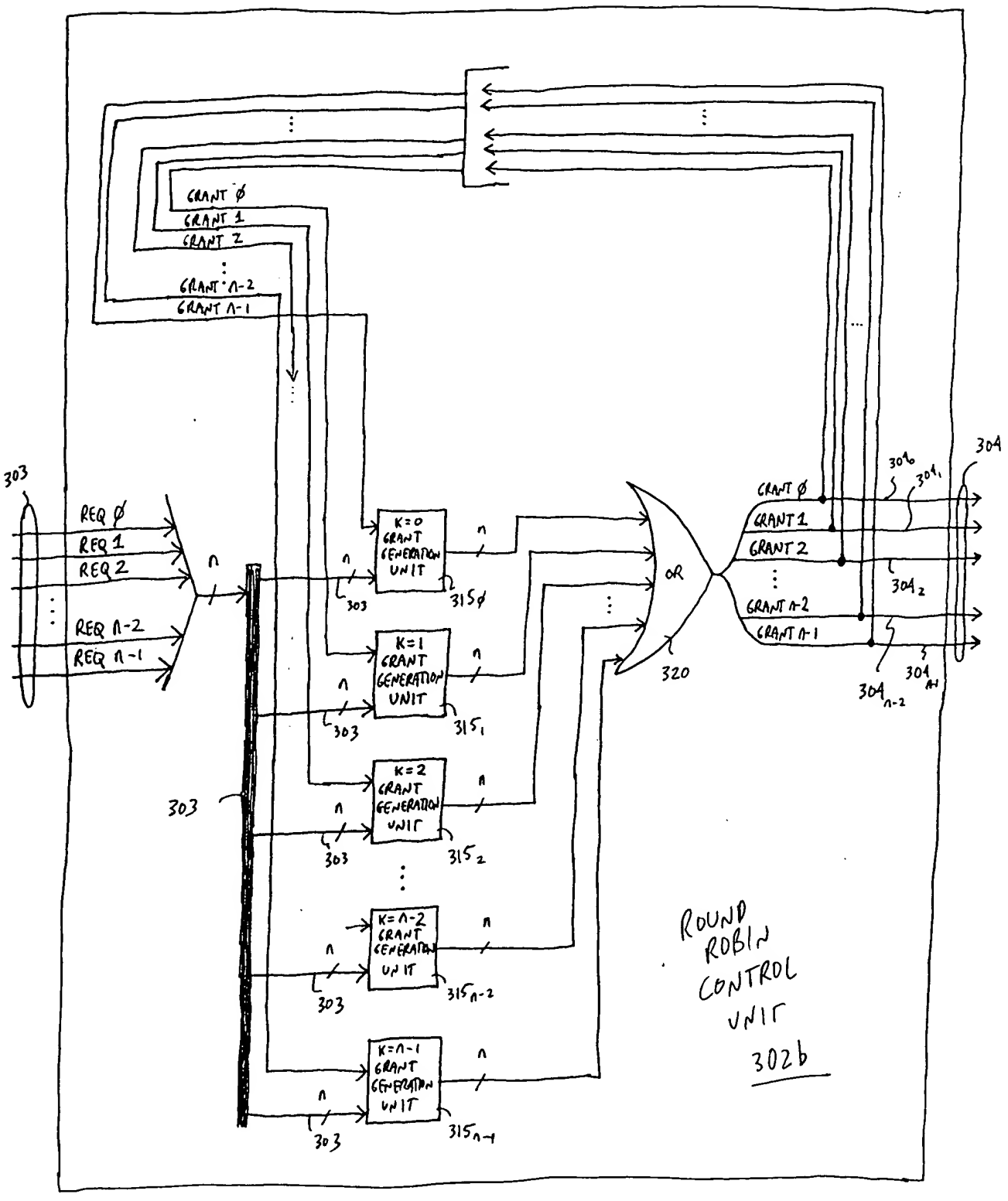
GRANT Ø
GRANT 1
GRANT 2
GRANT n-2
GRANT n-1
303
REQ Ø
REQ 1
REQ 2
REQ n-2
REQ n-1
n
K=0 GRANT GENERATION UNIT
K=1 GRANT GENERATION UNIT
K=2 GRANT GENERATION UNIT
K=n-2 GRANT GENERATION UNIT
K=n-1 GRANT GENERATION UNIT
315Ø
315₁
315₂
315n-2
315n-1
OR
320
304
304Ø
304₁
304₂
304n-2
304n-1
ROUND ROBIN CONTROL UNIT 302b

FIGURE 3b

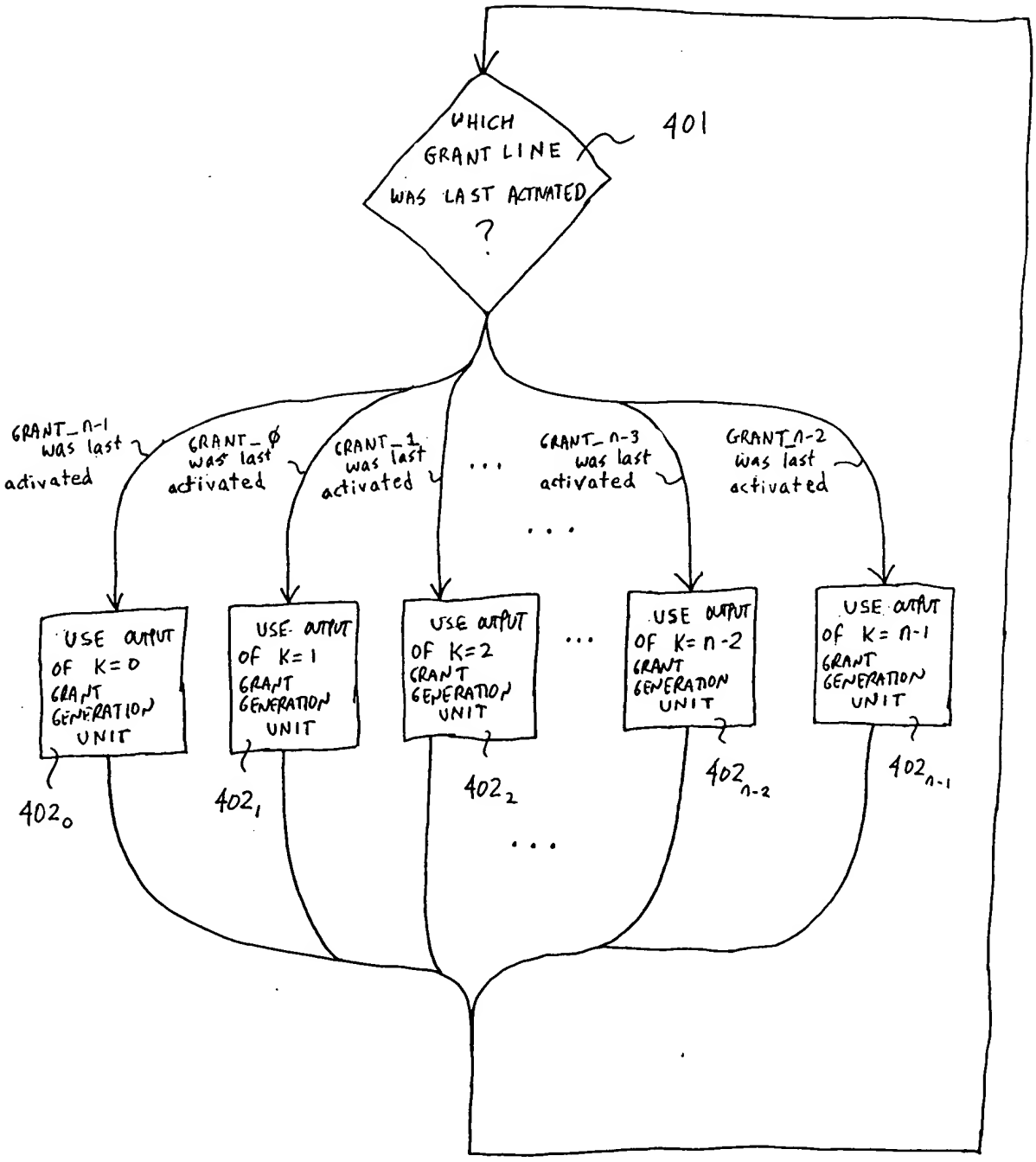

FIGURE 4

400

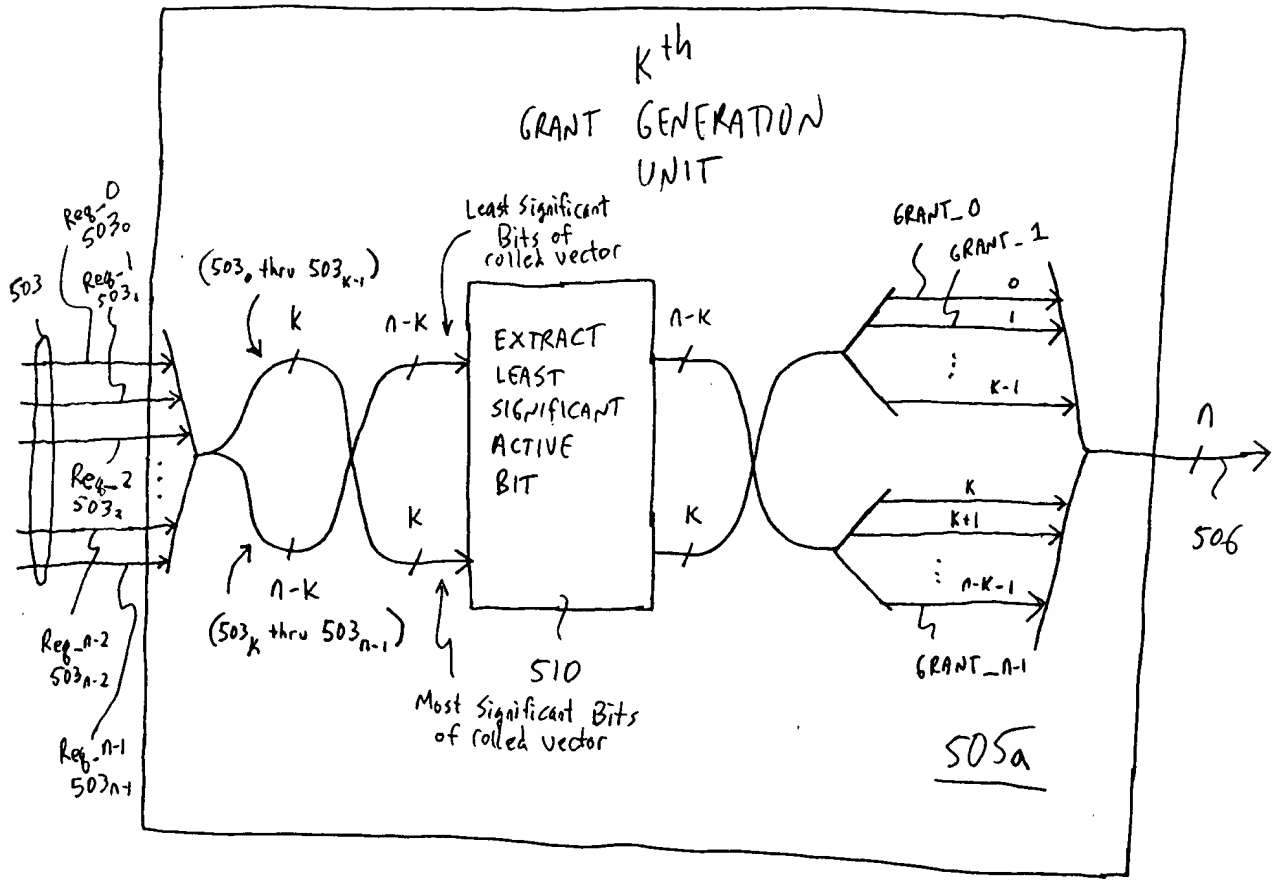

FIGURE 5a

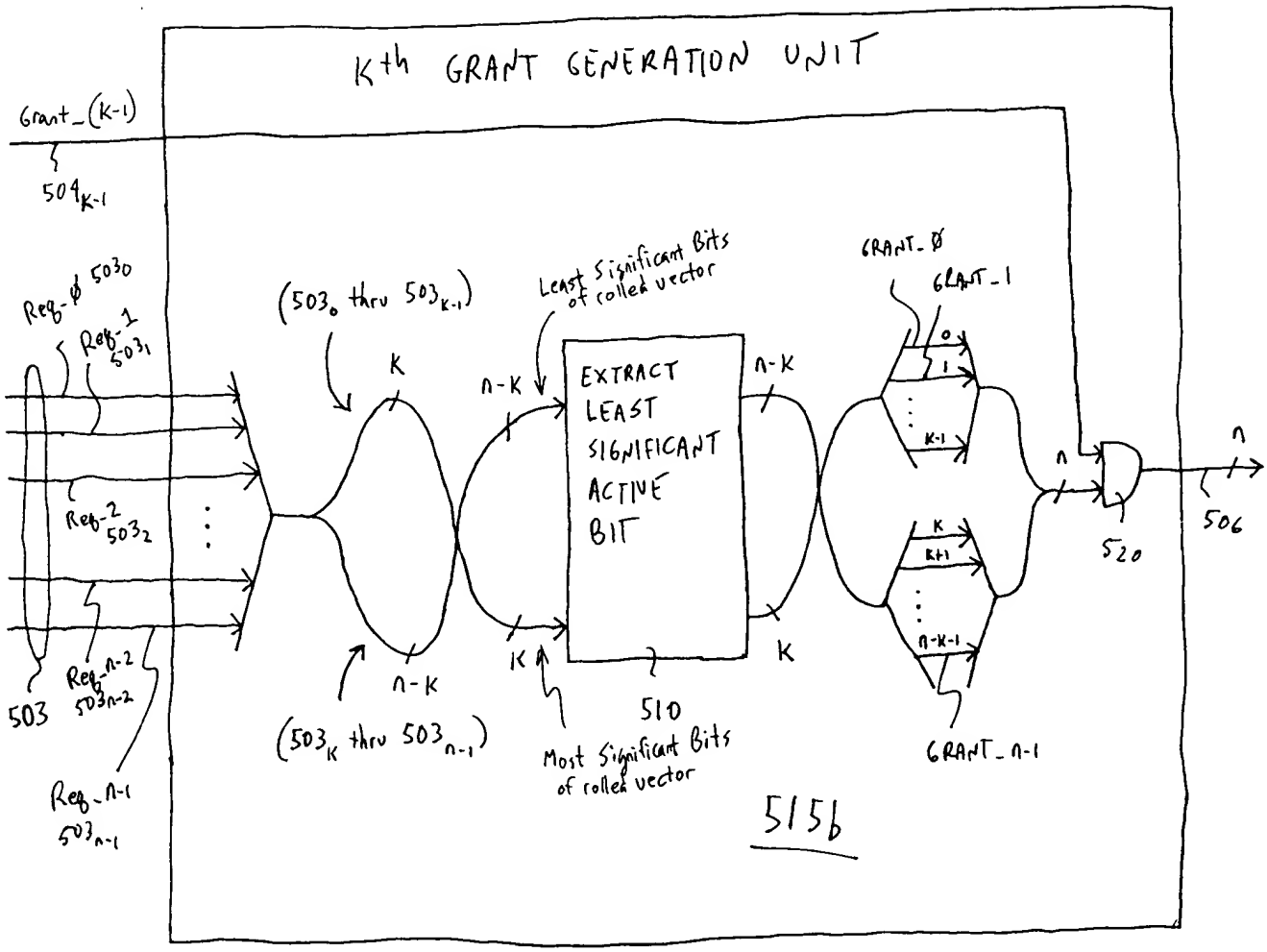

FIGURE 5b

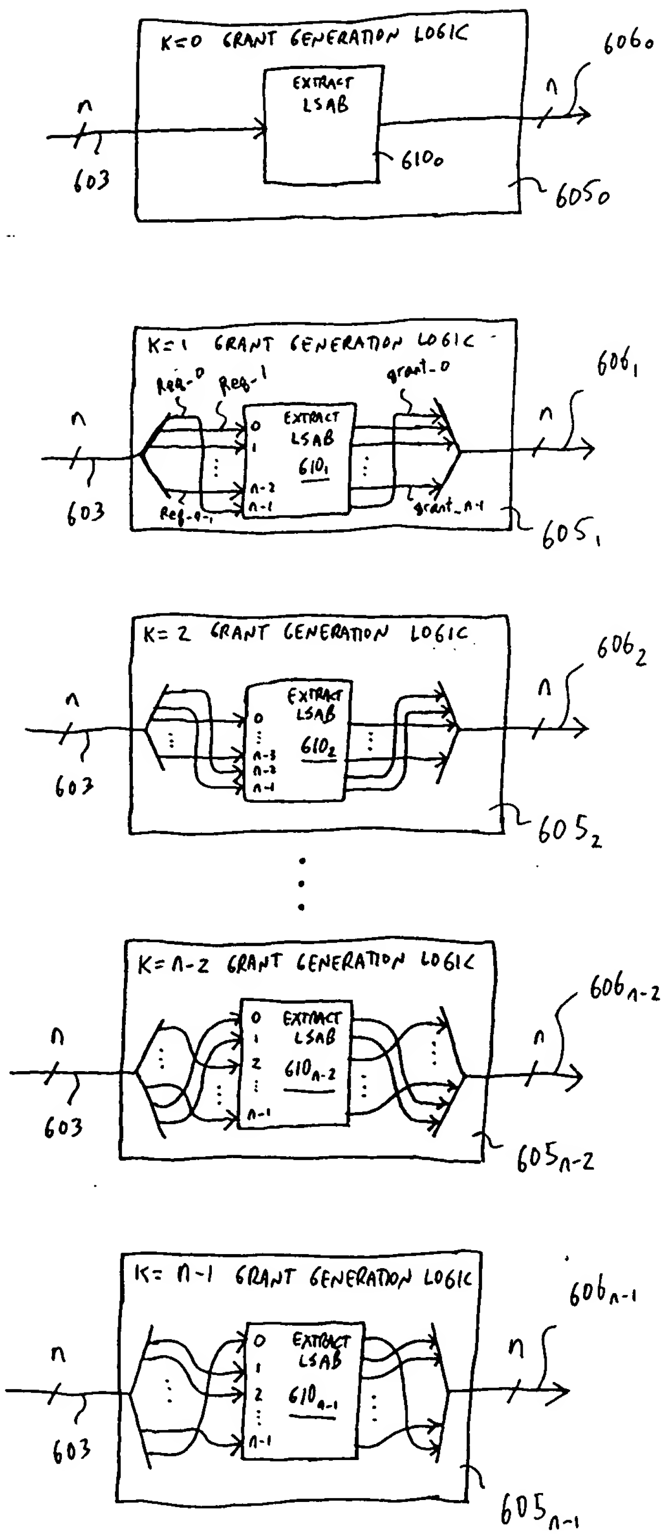
K=0 GRANT GENERATION LOGIC
EXTRACT LSAB
n
603
610₀
606₀
605₀
K=1 GRANT GENERATION LOGIC
Req-0
Req-1
grant-0
EXTRACT LSAB
610₁
Req-n-1
grant_n-1
606₁
605₁
K=2 GRANT GENERATION LOGIC
EXTRACT LSAB
610₂
606₂
605₂
K=n-2 GRANT GENERATION LOGIC
EXTRACT LSAB
610ₙ₋₂
606ₙ₋₂
605ₙ₋₂
K=n-1 GRANT GENERATION LOGIC
EXTRACT LSAB
610ₙ₋₁
606ₙ₋₁
605ₙ₋₁

FIGURE 6

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```
module rr (dataIn, state, dataOut) /* synthesis syn_hier = "flatten,remove" */;

input [19:0]     dataIn;
input [19:0]     state;
output [19:0]    dataOut;

wire [19:0]           dataOut0, dataOut1, dataOut2, dataOut3, dataOut4,
                      dataOut5, dataOut6, dataOut7, dataOut8, dataOut9,
                      dataOut10, dataOut11, dataOut12, dataOut13, dataOut14,
                      dataOut15, dataOut16, dataOut17, dataOut18, dataOut19;

prio prio0 (.dataIn(dataIn), .en(state[19]),
            .dataOut(dataOut0));

prio prio1 (.dataIn({dataIn[0], dataIn[19:1]}), .en(state[0]),
            .dataOut({dataOut1[0], dataOut1[19:1]}));

prio prio2 (.dataIn({dataIn[1:0], dataIn[19:2]}), .en(state[1]),
            .dataOut({dataOut2[1:0], dataOut2[19:2]}));

prio prio3 (.dataIn({dataIn[2:0], dataIn[19:3]}), .en(state[2]),
            .dataOut({dataOut3[2:0], dataOut3[19:3]}));

prio prio4 (.dataIn({dataIn[3:0], dataIn[19:4]}), .en(state[3]),
            .dataOut({dataOut4[3:0], dataOut4[19:4]}));

prio prio5 (.dataIn({dataIn[4:0], dataIn[19:5]}), .en(state[4]),
            .dataOut({dataOut5[4:0], dataOut5[19:5]}));

prio prio6 (.dataIn({dataIn[5:0], dataIn[19:6]}), .en(state[5]),
            .dataOut({dataOut6[5:0], dataOut6[19:6]}));

prio prio7 (.dataIn({dataIn[6:0], dataIn[19:7]}), .en(state[6]),
            .dataOut({dataOut7[6:0], dataOut7[19:7]}));

prio prio8 (.dataIn({dataIn[7:0], dataIn[19:8]}), .en(state[7]),
            .dataOut({dataOut8[7:0], dataOut8[19:8]}));

prio prio9 (.dataIn({dataIn[8:0], dataIn[19:9]}), .en(state[8]),
            .dataOut({dataOut9[8:0], dataOut9[19:9]}));

prio prio10 (.dataIn({dataIn[9:0], dataIn[19:10]}), .en(state[9]),
             .dataOut({dataOut10[9:0], dataOut10[19:10]}));

prio prio11 (.dataIn({dataIn[10:0], dataIn[19:11]}), .en(state[10]),
             .dataOut({dataOut11[10:0], dataOut11[19:11]}));

prio prio12 (.dataIn({dataIn[11:0], dataIn[19:12]}), .en(state[11]),
             .dataOut({dataOut12[11:0], dataOut12[19:12]}));

prio prio13 (.dataIn({dataIn[12:0], dataIn[19:13]}), .en(state[12]),
             .dataOut({dataOut13[12:0], dataOut13[19:13]}));

prio prio14 (.dataIn({dataIn[13:0], dataIn[19:14]}), .en(state[13]),
             .dataOut({dataOut14[13:0], dataOut14[19:14]}));

prio prio15 (.dataIn({dataIn[14:0], dataIn[19:15]}), .en(state[14]),
             .dataOut({dataOut15[14:0], dataOut15[19:15]}));

prio prio16 (.dataIn({dataIn[15:0], dataIn[19:16]}), .en(state[15]),
             .dataOut({dataOut16[15:0], dataOut16[19:16]}));

prio prio17 (.dataIn({dataIn[16:0], dataIn[19:17]}), .en(state[16]),
             .dataOut({dataOut17[16:0], dataOut17[19:17]}));

prio prio18 (.dataIn({dataIn[17:0], dataIn[19:18]}), .en(state[17]),
             .dataOut({dataOut18[17:0], dataOut18[19:18]}));

prio prio19 (.dataIn({dataIn[18:0], dataIn[19]}), .en(state[18]),
             .dataOut({dataOut19[18:0], dataOut19[19]}));

assign dataOut = ((dataOut0 | dataOut1 | dataOut2 | dataOut3) |
                  (dataOut4 | dataOut5 | dataOut6 | dataOut7) |
                  (dataOut8 | dataOut9 | dataOut10 | dataOut11) |
                  (dataOut12 | dataOut13 | dataOut14 | dataOut15) |
                  (dataOut16 | dataOut17 | dataOut18 | dataOut19));
endmodule // rr
```

FIGURE 7

Figure 4. The "round robin" top level Verilog module for N=20

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FIGURE 8

```
module prio (dataIn, en, dataOut);
input [19:0]      dataIn;
input             en;
output [19:0]     dataOut;

reg [19:0]      i_dataOut0;


always @(/*AUTOSENSE*/dataIn) begin
  i_dataOut0 = 20'd0;
  if (dataIn[0])        i_dataOut0 = 20'h00001;
  else if (dataIn[1])   i_dataOut0 = 20'h00002;
  else if (dataIn[2])   i_dataOut0 = 20'h00004;
  else if (dataIn[3])   i_dataOut0 = 20'h00008;
  else if (dataIn[4])   i_dataOut0 = 20'h00010;
  else if (dataIn[5])   i_dataOut0 = 20'h00020;
  else if (dataIn[6])   i_dataOut0 = 20'h00040;
  else if (dataIn[7])   i_dataOut0 = 20'h00080;
  else if (dataIn[8])   i_dataOut0 = 20'h00100;
  else if (dataIn[9])   i_dataOut0 = 20'h00200;
  else if (dataIn[10])  i_dataOut0 = 20'h00400;
  else if (dataIn[11])  i_dataOut0 = 20'h00800;
  else if (dataIn[12])  i_dataOut0 = 20'h01000;
  else if (dataIn[13])  i_dataOut0 = 20'h02000;
  else if (dataIn[14])  i_dataOut0 = 20'h04000;
  else if (dataIn[15])  i_dataOut0 = 20'h08000;
  else if (dataIn[16])  i_dataOut0 = 20'h10000;
  else if (dataIn[17])  i_dataOut0 = 20'h20000;
  else if (dataIn[18])  i_dataOut0 = 20'h40000;
  else if (dataIn[19])  i_dataOut0 = 20'h80000;
end

assign dataOut = {20{en}} & i_dataOut0;

endmodule // prio
```

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Figure 5. The basic "brute force" verilog implementation of the "prio" module for N=20. This generates the smallest area but is slower than the alternative implementation shown next.

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FIGURE 9

```
module prio (dataIn, en, dataOut) /* synthesis syn_hier = "flatten,remove" */;
input [19:0]     dataIn;
input            en;
output [19:0]    dataOut;

reg [4:0]        i_dataOut0;
reg [4:0]        i_dataOut1;
reg [4:0]        i_dataOut2;
reg [4:0]        i_dataOut3;
wire [9:0]      i_dataOut4;
wire [9:0]      i_dataOut5;

wire            muxCtl1;
wire            muxCtl2;
wire            muxCtl3;

// Calc in parallel
assign muxCtl1 = |dataIn[4:0];
assign muxCtl2 = |dataIn[14:10];
assign muxCtl3 = |dataIn[9:5] | muxCtl1;

always @(/*AUTOSENSE*/dataIn) begin
  i_dataOut0 = 5'd0;
  if (dataIn[0])        i_dataOut0 = 5'h01;
  else if (dataIn[1])   i_dataOut0 = 5'h02;
  else if (dataIn[2])   i_dataOut0 = 5'h04;
  else if (dataIn[3])   i_dataOut0 = 5'h08;
  else if (dataIn[4])   i_dataOut0 = 5'h10;
end // always @ (...

always @(/*AUTOSENSE*/dataIn) begin
  i_dataOut1 = 5'd0;
  if (dataIn[5])        i_dataOut1 = 5'h01;
  else if (dataIn[6])   i_dataOut1 = 5'h02;
  else if (dataIn[7])   i_dataOut1 = 5'h04;
  else if (dataIn[8])   i_dataOut1 = 5'h08;
  else if (dataIn[9])   i_dataOut1 = 5'h10;
end // always @ (...

always @(/*AUTOSENSE*/dataIn) begin
  i_dataOut2 = 5'd0;
  if (dataIn[10])       i_dataOut2 = 5'h01;
  else if (dataIn[11])  i_dataOut2 = 5'h02;
  else if (dataIn[12])  i_dataOut2 = 5'h04;
  else if (dataIn[13])  i_dataOut2 = 5'h08;
  else if (dataIn[14])  i_dataOut2 = 5'h10;
end // always @ (...

always @(/*AUTOSENSE*/dataIn) begin
  i_dataOut3 = 5'd0;
  if (dataIn[15])       i_dataOut3 = 5'h01;
  else if (dataIn[16])  i_dataOut3 = 5'h02;
  else if (dataIn[17])  i_dataOut3 = 5'h04;
  else if (dataIn[18])  i_dataOut3 = 5'h08;
  else if (dataIn[19])  i_dataOut3 = 5'h10;
end // always @ (...

// "Mux" data out
assign i_dataOut4 = {i_dataOut1 & {5{~muxCtl1}}, i_dataOut0 & {5{muxCtl1}}};
assign i_dataOut5 = {i_dataOut3 & {5{~muxCtl2}}, i_dataOut2 & {5{muxCtl2}}};
assign dataOut = {i_dataOut5 & {10{en & ~muxCtl3}}, i_dataOut4 & {10{en & muxCtl3}}};

endmodule // prio
```

901 902 903 904 905 →

Figure 6. Alternative "prio" module Verilog implementation.